CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM
SBIR 09.1 Proposal Submission

General Information

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) required the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) Program into a single office – Office of the Special Assistant, Chemical and Biological Defense and Chemical Demilitarization Programs. The Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD), Defense Threat Reduction Agency (DTRA) provides the management for the Science and Technology component of the Chemical and Biological Defense Program. Technologies developed under the SBIR Program have the potential to transition to the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) if the appropriate level of technology maturity has been demonstrated. The JSTO-CBD Science & Technology programs and initiatives are improving defensive capabilities against Chemical and Biological Weapons. The Small Business Innovation Research (SBIR) portion of the CBD Program is managed by the JSTO-CBD through the Army SBIR Program Management Office (PM, SBIR), Ft. Belvoir, VA.

The mission of the Chemical and Biological Defense Program is to ensure that the U.S. military has the capability to operate effectively and decisively in the face of chemical or biological warfare threats at home or abroad. Numerous factors continually influence the program and its technology development priorities, including planning for war-fighting support to asymmetrical threats, the evolving geopolitical environment, development of new threat materials, the threat of global proliferation of chemical and biological weapons, and available DoD resources. Improved defensive capabilities are essential in order to minimize the impact of such weapons. The U.S. military requires the finest state-of-the-art equipment and instrumentation available that permits our warfighters to detect, warn and avoid contamination, if possible, and to be able to sustain operations in a potentially contaminated environment through protection and decontamination. Further information regarding the DoD Joint Chemical and Biological Defense Program is available at the DoD Counterproliferation and Chemical Biological Defense homepage at http://www.acq.osd.mil/cp.

The overall objective of the CBD SBIR Program is to improve the transition or transfer of innovative Chem-Bio technologies to the end user – the warfighter – in addition to commercializing technologies within the private sector for mutual benefit. The CBD SBIR Program targets those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection for both point and stand-off capabilities; individual and collective protection; hazard mitigation (decontamination); information systems technology to include but not limited to modeling and simulation; basic and supporting sciences; medical pre-treatments (e.g., vaccine development and delivery); medical diagnostics; and medical therapeutics (chemical countermeasures and biological countermeasures).

Submitting Your Phase I CBD SBIR Proposal

Your entire proposal (consisting of Proposal Cover Sheets, the full Technical Proposal, Cost Proposal, and Company Commercialization Report) must be submitted electronically through the DoD SBIR/STTR Proposal Submission system located at www.dodsbir.net/submission. A hardcopy is NOT required for CBD. Hand or electronic signature on the proposal is also NOT required.

You must prepare a Company Commercialization Report through the Submission site and it will be included with your electronic submission; however, it does not count against the proposal page limit. Update your commercialization information if you have not done so in the past year. Please note that improper handling of the Commercialization Report may result in the proposal being substantially delayed, and that information provided may have a direct impact on the review of the proposal. Refer to section 3.5d at the program solicitation for detailed instructions on the Company Commercialization Report.

Be reminded that section 3.5.a of this solicitation states: "If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary or classified information in these sections". Note also that the DoD web site contains timely information on firm, award, and abstract data for all DoD SBIR Phase I and II awards archived for several years. This information can be viewed on the DoD SBIR/STTR Web site at http://www.acq.osd.mil/osbp/sbir/.

The CBD SBIR Program has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that may be exercised to fund interim Phase II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I feasibility study is $70,000. The Phase I Option, which **must** be proposed as part of the Phase I proposal, covers activities over a period of up to three months and at a cost not to exceed $30,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities, which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The CBD SBIR Program will not accept Phase I proposals which exceed $70,000 for the Phase I effort and $30,000 for the Phase I Option effort**. Only those Phase I efforts selected for Phase II awards through the CBD SBIR Program's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $850,000, the total funding amount available for Phase II activities under a resulting Phase II contract will be $750,000.

Companies submitting a Phase I proposal under this Solicitation must complete the Cost Proposal using the on-line form within a total cost of $70,000 over a period of up to six (6) months (plus up to $30,000 for the Phase I Option over a period of up to three (3) months). Phase I and Phase I Option costs must be shown separately.

Selection of Phase I proposals will be based upon the evaluation procedures and criteria discussed in section 4.2. The CBD SBIR Program reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality in the judgment of the technical evaluation team will be funded.

Proposals not conforming to the terms of this solicitation, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

CBD Program Phase II Proposal Guidelines

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which achieved success in Phase I, as determined by the project technical monitor measuring the results achieved against the criteria contained in section 4.3, will be invited to submit a Phase II proposal. During or at the end of the Phase I effort, awardees will be invited to submit proposals for evaluation for a Phase II award based on the results of the Phase I effort. The invitation will be issued in writing by the organization responsible for awarding the Phase I effort. Invited proposers are

required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Proposers are required to submit a budget for the entire 24 month Phase II period. During contract negotiation, the contracting officer may require a cost proposal for a base year and an option year, thus, proposers are advised to be mindful of this possibility. These costs must be submitted using the Cost Proposal format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. At the Contracting Officer's discretion, Phase II projects may be evaluated after the base year prior to extending funding for the option year.

The CBD SBIR Program is committed to minimizing the funding gap between Phase I and Phase II activities. All CBD SBIR Phase II proposals will receive expedited reviews and be eligible for interim funding (refer to the preceding paragraph for information on the Phase I Option). Accordingly, all Phase II proposals will be evaluated within a single multi-tiered evaluation process and schedule. Phase II proposals will thus typically be submitted within five (5) months from the scheduled DoD Phase I award date (the scheduled DoD award date for Phase I, subject to the Congressional Budget process, is 4 months from close of the DoD Solicitation). The CBD Program typically funds a cost–plus fixed-fee Phase II award, but may award a firm-fixed price contract at the discretion of the Contracting Officer.

Key Dates

09.1 Solicitation Open/Close	8 December 2008 – 14 January 2009
Phase I Evaluations	January - March 2009
Phase I Selections	March 2009
Phase I Awards	May 2009*
Phase II Invitations	October 2009
Phase II Proposals due	November 2009

*Subject to the Congressional Budget process.

CBD SBIR PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the CBD SBIR requirements. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award**.

_____ 1. The Proposal Cover Sheets along with the Technical Proposal, Cost Proposal and Company Commercialization Report are submitted via the Internet using the DoD's SBIR/STTR Proposal Submission Web site at http://www.dodsbir.net/submission.

_____ 2. The proposal cost adheres to the CBD Program criteria specified.

_____ 3. The proposal is limited to only **ONE** solicitation topic. All required documentation within the proposal references the same topic number.

_____ 4. The Project Abstract and other content provided on the Proposal Cover Sheet contains no proprietary or classified information and is limited to the space provided.

_____ 5. The Technical Content of the proposal, including the Option (if applicable), includes the items identified in Section 3.4 of the solicitation.

_____ 6. The Proposal Cover Sheets and technical proposal is 25 pages or less in length. The Cost Proposal and Company Commercialization Report do not count against the 25 page limit. Pages in excess of this length will not be considered for review or award.

_____ 7. The Company Commercialization Report is submitted online in accordance with Section 3.5.d. This report is required even if the company has not received any SBIR funding.

_____ 8. The proposal contains no type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

CBD SBIR 091 Topic Index

CBD SBIR 091 Topic Descriptions

CBD09-101 TITLE: Nanotechnology Anti-fog Coating Process for Respiratory Protection Systems

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Biomedical

OBJECTIVE: Design and develop a robust nanotechnology processing and fabrication technique for the deposition of anti-fog coatings on lenses of respiratory protection systems.

DESCRIPTION: The Department of Defense (DOD) has a continuing need for anti-fog coatings. In particular, respiratory protection systems have demonstrated a diminished visual performance capability in certain environmental extremes. Currently available anti-fog coatings degrade in performance as a result of cleaning and sanitization procedures. Emerging nanotechnology processes offer a variety of techniques that are suitable for developing an innovative high performance anti-fog coating. Superhydrophobic and superhydrophilic surfaces can be produced by depositing nanoparticles on the substrate surface or by creating roughness on the surface. Nanoparticles are typically deposited on surfaces using sol-gel chemistry,1 dip coating, and spin coating. Surface roughness can be attained using a phase separation technique that produces a porous material2 or by using lithography to create micropillars.3 Layer-by-layer assembly can be used to control the design of physical and chemical properties of the coating.4 However, many of these processes have drawbacks related to cost, adhesion characteristics, and durability. Novel approaches such as hydrothermal treatments5 to improve the durability of these coatings will be necessary.

Thus, a process is needed that will allow for the permanent application of anti-fog coatings in a consistent and durable fashion. Combinations of the above techniques will likely be needed. The process must be low cost and versatile to allow for the development of superhydrophilic and superhydrophobic coatings on flexible polyurethane and hard coated polycarbonate lens surfaces. Anti-fog coatings must be extremely resistant to abrasion, water, sanitization solutions, manufacturing cleaners, and environmental extremes from -60F – 160F. Applied anti-fog coatings must not degrade optical properties of the lens and shall not yellow, haze, or crack as a result of UV exposure or environmental storage. The process will allow for the coating of cylindrical, toroidal, or spherical lens surfaces in a reliable and continuous process. The resulting coatings will provide DOD with an improved capability and improved warfighter performance in environmental extremes while maintaining service durability and reducing logistical burden.

PHASE I: Demonstrate the feasibility of fabricating anti-fog coatings ranging from superhydrophilic to superhydrophobic utilizing a low cost and consistent process. Develop coated lens material, lenses, or film inserts demonstrating the process's range of performance and demonstrate potential of coating to exceed capabilities of current anti-fog coating technology and procedures. Identify key operational and fabrication characteristics that cause current coatings to fail and assess performance of proposed solution(s) against these failure mechanisms using standard test methods where applicable.

PHASE II: Refine and optimize the process to develop a full scale continuous process suitable for coating lenses of various geometric shapes. Select process conditions resulting in the optimal anti-fog performance under conditions consistent with the dynamic respiratory protection application. Demonstrate functional anti-fog performance in extreme hot and cold environments. Fully demonstrate the durability of the coating by assessing mechanical and chemical resistance under operational conditions. Fully demonstrate material and process options specific to various applications needed for military and commercial needs. Perform environmental exposure tests and modify process variables to improve and optimize product performance. Assess and validate optical performance under all conditions consistent with optical standards.

PHASE III: Apply the process to military applications to include: battlefield goggles, laser protection, ballistic shields, and transparent armor panels. Expand applications to commercial markets to include: industrial and homeland defense respirators, sport goggles, windshields, and window panels. Investigate applications such as anti-soiling, water repellency, and textile treatment that would expand commercial application of the process technology.

REFERENCES:

1. Liu Y, Chen X, Xin JH. Super-hydrophobic surfaces from a simple coating method: a bionic nanoengineering approach. Nanotechnology 17:3259-63 (2006).

2. Shirtcliffe NJ, McHale G, Newton MI, Perry CC, Roach P. Porous materials show superhydrophobic to superhydrophilic switching. Chem. Commun., 3135-37 (2005).

3. McHale G, Shirtcliffe NJ, Aqil S, Perry CC, Newton MI. Topography Driven Spreading. Phys. Rev. Lett. 93, 036102 (2004).

4. Cebeci FC, Wu Z, Zhai L, Cohen RE, Rubner MF. Nanoporosity-driven superhydrophilicity: a means to create multifunctional antifogging coatings. Langmuir 22:2856-62 (2006).

5. Gemici, Z, Shimomura, H, Rubner, MF, Cohen, RE. Hydrothermal treatment of nanoparticle thin films for enhanced mechanical durability. Langmuir, 24, 2168-2177 (2008).

KEYWORDS: Anti-fog coatings, respiratory protection, lens, nanotechnology, superhydrophilicity, superhydrophobicity.

CBD09-102 TITLE: Bio-Inspired Dry Adhesives

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Design and fabricate a fibrillar dry adhesive to enhance the sealing performance of a full-facepiece respiratory protective mask.

DESCRIPTION: While man-made adhesives rely on viscoelasticity and chemical interactions, many biological species, including the gecko, use elasticity, van der Waals forces, structural design, and possibly capillary forces to rapidly attach and detach from surfaces to optimize both adhesion and locomotion. Geckos, spiders, beetles, flies, and many other climbing lizards and insects have a variety of micrometer or nanometer scale sized, single or multi-layer, dry or oil-coated, high or low density (and aspect ratio) hairs or other structures on their appendages (feet) to efficiently stick and climb on a wide range of smooth or rough surfaces. These micro/nano-structures adapt to surface roughness by preloading and dragging. They enable strong, robust, and repeatable attachment and detachment, and are self-cleaning against dirt and contaminants on surfaces.

Researchers at many institutions around the world are investigating bio-mimetic dry adhesives.1 Their research has greatly expanded our knowledge of the basic characteristics of dry adhesives and has led to various mathematical models and fabricated dry adhesives. 1,2

The current effort would develop a novel, bio-mimetic dry adhesive to enhance the sealing of a respiratory protective mask. The adhesive would ensure that the mask peripheral seal maintains good contact with the facial skin surface in the presence of sweat, oils, dirt, facial hair, or acne and would help to prevent the mask from sliding around on the face, thus preventing leakage. The polymer used to fabricate the bio-inspired adhesive must be hygienic, durable, and easy to clean. The backing material used to support the fibrillar surface should be able to be integrated with the existing peripheral seal of the mask. The adhesive must be able to withstand a large range of temperature and environmental extremes and must be resistant to chemical, biological, and non-traditional threat agents.

PHASE I: Identify required adhesion, friction, and shear forces for sealing a full-facepiece respirator to the face without a head harness or with only minimal support. Develop a model of fibrillar attachment on dry and wet skin. Fabricate sample dry adhesives and test on skin or a synthetic substitute. Compare the model predictions and adhesive test results to demonstrate the feasibility of using the model to design a dry adhesive for this application. Identify key design characteristics (fiber geometry, material properties, and required forces) based on the model and test results.

PHASE II: Optimize the model of skin attachment and further develop the dry adhesive materials to enhance sealing on wet, dirty, and unshaven skin. Fabricate samples that can be used in conjunction with the peripheral seal of a full-facepiece respirator. Demonstrate the self-cleaning properties of the dry adhesives. Demonstrate enhanced sealing performance under various conditions including skin that is dirty, unshaven, or sweaty. Demonstrate the impact of segmentation of the micro/nano-structures on adhesion and sealing performance.

PHASE III DUAL-USE COMMERCIALIZATION: This phase includes further development of the dry adhesives to improve self-cleaning, attachment & detachment forces, and durability. These adhesives have the potential for use in both military and commercial applications including seals for protective clothing and collective protection systems as well as such diverse products as wall-climbing robots and plastic storage bags.

REFERENCES:
1. http://robotics.eecs.berkeley.edu/~ronf/Gecko/gecko-biblio.html

2. Autumn, K (2006) Properties, principles, & parameters of the gecko adhesive system. In Biol Adh, eds. Smith & Callow, pp. 225-255. Berlin: Springer Verlag.

CBD09-103 TITLE: Real Time Detection of Trace Amounts of Methyl Salicylate

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop a near-real time sensor system capable of measuring the exposure of the skin beneath a protective garment to a chemical agent simulant (methyl salicylate – MeS). This is part of a test protocol to establish level of protection afforded by personal protective equipment for use in environments potentially contaminated with chemical agents. The sensor will measure infiltration of the MeS through the protective garment. The desired range of response is 500 nanograms (ng) per cubic meter up to the typical challenge level of 100 milligrams (mg) per cubic meter. The sensor should be able provide an accurate reading within 20 percent of the refereed concentration within 30 seconds. The ability to achieve the required sensitivities and accuracies for the exposure concentrations is a critical milestone in this development effort. The sensors will be worn by human test subjects who are performing physical activity while wearing protective garments. The sensor system must be able to function accurately in a rapidly fluctuating (concentration and air flow) environment, and operate from a 0 to 40 degrees Celsius, operate in a high humidity (>90% Relative Humidity) environment, and not be adversely impacted as a result of exposure to environmental factors to include human sweat, and human body odors. The sensor system must be small and/or conformal so it may be placed in a number of body regions (sufficient to cover areas likely to leak, track leak flow patterns, and monitor sensitive regions), not inhibit free movement of the test subject, and not attenuate, enhance or redirect normal circulation of air beneath the garment. The sensor system must integrate with central data telemetry and/or a data logging system and have sufficient on-board power for mission duration (4 to 8 hours).

DESCRIPTION: Recent advances in detection technologies and semiconductor development are making possible systems that can selectively detect chemical vapors in trace quantities. This will permit the measurement and tracking of chemical agents after an initial chemical breakthrough, or if leaks should occur in protective clothing while worn by active military personnel. A near real time system will provide a stream of data over the duration of a test and allow for an understanding of air currents between the protective garment and the skin.

PHASE I: Identify a detection technology that will achieve the stated objectives listed above. Develop a breadboard laboratory prototype for demonstrating proof of concept/ feasibility. Investigate detection technologies options (the active sensor), sensor replacement capability, sensitivities (detection limits), resistance to moisture and salts, and size. The proposed detection technology will be demonstrated to show that detection limits are achievable and that other desired properties are attainable. Additionally, a referee system capable of evaluating and calibrating the sensor down to the lower detection limit will be investigated and designed. A survey and comparative analysis of suitable telemetry and/or data logging systems as well as a preliminary design of the data analysis software will be completed. Additionally, provide an initial draft of the modifications to the existing Man-In-Simulant Test (MIST) protocol to accommodate and exploit advantages of the sensor system. This protocol will be provided to the selected offerors during the Phase I period of performance.

PHASE II: There are two sequential hardware developments that comprise Phase II: 1) sensor development, and 2) test system development, with system testing conducted at specific points during Phase II.

A MeS sensor will be developed from the Phase 1 technology demonstration. A referee system for testing and calibration of the sensor will also be constructed and validated. Testing will be performed at concentration levels that range from 100 ng/cubic meter through 100 mg/cubic meter, or until the sensor saturates while a person performs various physical activities. Test results will be analyzed and the sensor sensitivity will be graphed relative to a referee system.

Following the development and testing described above, the sensor will be modified based on the results. The sensor support circuitry will also be miniaturized to a practical size for usage as intended. The sensor telemetry system and/or logging system and data collection and analysis systems will also be developed and integrated at this stage. The analysis system should be able to produce the time-concentration history of each body region measured and tie specific body movement events to recorded failures (leaks). The system will be verified during multiple trials in a Man-In-Simulant Test (MIST) chamber and the overall suitability of the equipment and test protocol will be evaluated.

PHASE III / DUAL USE: The proposed sensor has potential use in numerous applications, particularly in various laboratories as a gas detection system. Various commercial industrial hygiene applications would also benefit from this development. The range of detection could be adjusted from extremely low level detection of gasses (with MeS or other detectable compounds), or gross detection of laboratory chemicals, or the ability to detect vapor leakage in overpressure environments. The sensor system also can be used to evaluate commercial protective ensembles (e.g., first responder personnel).

REFERENCES:
1. http://www.astm.org/Standards/F2588.htm

2. http://www.worldcat.org/oclc/38199764

3. http://www.chem-bio.com/resource/1999/cw_irp_ffpe_summary.pdf

4. http://www.dodsbir.net/Sitis/view_pdf.asp?id=CBD05-122Ref+3.pdf

5. http://www.natick.army.mil/about/pao/2002/02-31.htm

KEYWORDS: detector, sensor, chemical sensor, methyl salicylate detector, semiconductor detector

CBD09-104 TITLE: Rapid, reproducible high throughput identification of protein variants

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective of this SBIR topic is to develop a low cost device for rapid, reproducible identification of protein variants from biological samples with high throughput.

DESCRIPTION: Biological diversity is encoded genetically in every organism and in many cases can be visualized phenotypically as differences in macroscopic traits such as eye or skin color. A less obvious phenotype is the substantial heterogeneity in the response of individuals to stressors, such as microbial attack. For example, infection by the same strain of Group A Streptococcus can present asymptomatically, cause streptococcal toxic shock syndrome, or cause necrotizing fasciitis depending on the individual; the outcome was shown to be primarily due to polymorphisms in the host's major histocompatability complex (1). A similar phenomenon is seen with the susceptibility of cystic fibrosis patients to Pseudomonas aeruginosa infection; expression of different alleles of a receptor protein correlate with different severities of infection (2). Whereas genetic diversity could be assayed by DNA sequencing or amplification techniques, the presence of pseudogenes and multiple alleles that may not be expressed combined with potential privacy issues due to the availability of patients' DNA sequence information dictate development of other technologies to assay protein polymorphisms.

A non-DNA based method to predict the potential outcome of exposure, whether from microbial, physical or environmental stress is desirable. Analysis of allozymes has been used for years in population genetics and involves separation of the enzyme variants by non-denaturing gel electrophoresis through matrices such as cellulose-acetate, polyacrylamide, or starch and then assaying for enzymatic activity. This is cumbersome, time and labor intensive, and not conducive to high throughput analyses. In anticipation of, and to allow direct correlations to be made between protein variation and responses to various stressors, a high throughput approach to rapidly and reproducibly analyze amino acid variants within proteins is clearly required.

PHASE I: The investigators will develop a means to discriminate between variants of a protein from a simple mixture as a proof-of-concept. The protein should be of interest to the DoD and to the Chemical and Biological Defense Program, and variants that differ from each other by as little as a single amino acid should be resolved. Although the conditions may be specific for the test protein and variants, the method should be adaptable for use with other proteins.

PHASE II: The investigators will develop a prototype device to separate and identify protein variants and demonstrate that it is functionally useful by analyzing biological samples (e.g., isolating a spot from a 2-dimensional gel or similar purification scheme and determine the composition) for protein variants of at least 2 proteins of interest. For example, this could be accomplished by using samples collected from parents and progeny of test animals of known genetic background for the protein of interest. The device developed in Phase II should be low cost, robust and fieldable (i.e., portable enough that it could be used in a forward medical hospital setting). Additionally, the investigators must present a plan that describes how the high-throughput capability will be maintained while at the same time, how miniaturization of the hardware will be accomplished for use in field environments.

DUAL USE APPLICATIONS: A device to analyze protein polymorphisms will find widespread use in medical and research communities; clinical applications; and will also address remote medical needs (civilian field hospitals).

REFERENCES:
1. Kotb, M., A. Norrby-Teglund, A. McGeer H. El-Sherbini, M. T. Dorak, A. Khurshid, K. Green, J. Peeples, J. Wade, G. Thomson, B. Schwartz, and D. E. Low. 2002. An immunogenetic and molecular basis for differences in outcomes of invasive group A streptococcal infections. Nature Med. 8:1398–1404.

2. De Rose, V., C Arduino, N. Cappello, R Piana, P Salmin, M Bardessono, M Goia, R Padoan, E Bignamini, D Costantini, G Pizzamiglio, V Bennato, C Colombo, AM Giunta and A Piazza. 2005. Fcc receptor IIA genotype and susceptibility to P. aeruginosa infection in patients with cystic fibrosis. European Journal of Human Genetics 13:96-101.

KEYWORDS: protein, separation, polymorphism

CBD09-105 TITLE: Bio-MEMs Agile Sensor Platforms and Communication Networks

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems

OBJECTIVE: Development of low cost sensor and communication networks via leveraging of the natural capabilities of calling insects. Recent developments allow direct bio-mechanical interfaces between insects and MEMS/micro-electronic devices. This will enable insects to carry miniature sensors of various types (such as reagent-less chemical detectors) as well as provide for communication of sensor and other data.

DESCRIPTION: Millions of years of evolution have endowed insects with abilities to communicate reliably over varying distances through the transmission and reception of characteristic chirping sounds. The spectral contents of insect calls can be quite complex, as evidenced by virtually unlimited patterns of repetition, sound timbre, inflection, and other characteristics. Crickets, katydids, and cicadas are perhaps only three of the thousands of types of singing insects that abound and count on auditory signaling for their survival [1,2,3,4]. Crickets have proven to be excellent subjects for studies of acoustic communication because their acoustic signals are loud, highly variable, and are

perceived almost immediately after being produced [5,6,7]. The spectra of male crickets lie in the frequency range of 4 to 5 kHz [8]. The chirp is generated due to friction of rubbing wings (a process called stridulation). These spectral characteristics lend themselves to the possibility of low-bandwidth message passing by modulating the natural acoustic communication capabilities of insects. Of particular interest is the passing of messages that originate from embedded sensors within the insect. By deploying swarms of sensor-equipped insects, hazardous chemicals in hard-to-reach areas may be detected. Likewise, such sensor swarms can detect the presence of life under rubble in rescue missions, as well as potential adversaries behind walls and other obstructions.

Recent developments in electro-biomechanical interfaces with insects are now able to form an exploitable organic platform. For example, implanted MEMS piezoelectric devices have been shown to extract energy from insect movements to power electronic devices [9]. Stridulation could be influenced by available piezoelectric MEMS devices that alter or sense the tensile or effective dimensional properties of an insect abdomen where the abdomen serves as a natural acoustic transducer. Such developments should lead to insect-based sensor and communication products for a wide variety of applications in both the military and civil realm.

PHASE I: Conduct a study of the sound production mechanisms and associated acoustic spectra of calling insects. Determine appropriate insect species, MEMS, chip-level sensor technologies, and energy harvesting / storage methods that can potentially be combined to systematically modulate the insect's call in a manner as to communicate information from the sensor. Mechanisms applying MEMS devices to modulate the calling spectra include localized electrical stimulus of insect musculature, or electro-mechanical means to alter the physical characteristics of sound producing membranes (e.g., by changing the tension of a vibrating surface). Identify appropriate sensors that can be embedded within the insect and detect human presence, hazardous chemicals, etc. (only one sensor type needs to be investigated). Potential energy sources for powering the MEMS, sensor, and any other on-board electronics need to be assessed. Methods to consider include electro-mechanical energy harvesting from the insect movements, thin film batteries, and other innovative low voltage, low current energy sources. Consider embedding of devices during gestational vs. adult life stages of the insects. Experimentation with insects is welcomed during this phase, but not essential for fulfilling Phase I objectives.

PHASE II: On the basis of the Phase I results, focus the selection of possible insect species, MEMS technologies, sensor types, and energy harvesting / storage methods. Devise an approach or approaches to reliably modulate insect morphology by applying electro-mechanical responses of the MEMS devices in a manner as to convey signals detected by the on-board sensors. Experimental evidence must be supplied to support any claim towards possible sensor signal modulation approach. Demonstrate the approach through prototypes that deploy live insects, sensors, MEMS, and energy harvesting / energy storage methods.

PHASE III: Apply prototype towards a repeatable production of sensor-equipped insects for field use. Draw on the techniques and experimentation of Phase II and other research efforts. Demonstrate applicability of method when swarms of insects are applied to detect people, chemicals, etc.
Military Application: Sensor-based insect swarms are potentially useful in the detection of "behind the wall" adversaries, as well as in the detection of potentially harmful substances not immediately observable by the warfighter. The approach should also be useful during search and rescue missions, where insects can crawl through rubble reaching trapped victims.

Commercial Application: The sensor-based concept described herein can be perfected and made available to civil search and rescue efforts. Likewise, law enforcement can apply the sensor-based insects in the detection of personnel and harmful substances during criminal investigations.

REFERENCES:
1. I. Potamitis, N. Fakotakis, "Acoustic Monitoring of Singing Insects," Proc. IEEE Int. Conf. Acoustics, Speech and Signal Processing (ICASSP), V.4, 2007. p. IV-721.

2. B. Webb, "Using Robots to Model Animals: A Cricket Test," Robotics and Autonomous Syst., 16, 1995, p.117.

3. B. Webb, "Robots, Crickets and Ants: Models of Neural Control of Chemotaxis and Phonotaxis," Neural Networks, 1998 special issue, 11, 1998, p.1479.

4. P. Vickers and J.L. Alty, “When Bugs Sing,” Interacting with Computers, 14, 2002, p.793.

5. Ewing, A.W. Arthropod bioacoustics. Neurobiology and behavior. Ithaca, NY: Cornell Univ. Press, 1989.

6. Prestwich K.N, Walker T.J. 1981. Energetics of singing in crickets: effect of temperature in three trilling species (Orthoptera: Gryllidae). J. Comp. Physiol. 143:199-212.

7. Walker, T.J. Factors responsible for intraspecific variation in the calling song of crickets. Evolution 16:407-428, 1962.

8. R.A. Wyttenbach, M.L. May and R.R. Hoy, "Categorical perception of Sound Frequency by Crickets," Science, Vol. 273, No. 5281, p.1542.

9. I. Sari, T. Balkan, H. Kulah, "An Energy Harvesting MEMS Frequency Detector," in IEEE Sensors, 28-31 October, 2007, pp. 1460-1463.

KEYWORDS: Bioinspired Platforms, Sensors, MEMS, Networking

CBD09-106 TITLE: Non-cryogenic Air/Vapor Stream Sampling System for Chemical Threats

TECHNOLOGY AREAS: Chemical/Bio Defense

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a compact, non-cryogenic air/vapor stream sampling system for capturing, concentrating and transferring chemical threats for analysis in swatch test fixtures and for field portable gas chromatography-mass spectrometry (GC-MS) detection.

DESCRIPTION: GC-MS is the most definitive technology currently available for the detection and monitoring of chemical threat agents. Although considerable progress has been made over the past 5 years to advance GC-MS instrumentation in areas of reliability, robustness, size and portability, the development of complementary air/vapor stream sampling technology has lagged behind. This is because of the difficulties encountered in sampling large air volumes, concentrating the analytes of interest, eliminating unwanted matrix interferents (such as water vapor, particulates, etc.), and transferring the analytes rapidly and efficiently to the detector. This topic is of particular interest to materiel testing, especially related to personal protective clothing and equipment for the warfighter, and for field portable detection of toxic chemical agents. There is a major need to develop new approaches for automated, real-time or near real-time, on-line air/vapor stream sampling and detection.

This SBIR project is aimed at encouraging the use of innovative approaches to develop an automated, simple, robust and reliable non-cryogenic air/vapor stream sampling technology for use in test fixtures (including Swatch, Emergency Responder Toxic Industrial Chemicals (ERTIC), Mask, and Glove & Boot test fixtures) and with field portable GC-MS detection. Specifically, the air/vapor sampling system should be able to (1) quantitatively trap and concentrate volatile and semi-volatile organic compounds from a 1 mL/min to 1 L/min gas flow at a concentration as low as 40 picograms/L, (2) eliminate water vapor from the sample stream with a relative humidity of 80+5%, and (3) deliver a narrow band of concentrated sample to the GC-MS at intervals ranging from 1 to 5 min.

There is considerable literature that describes various air sampling methodologies that are relevant to this project. Traditional air sampling involves passing a large volume of air through a solid sorbent (reference 1). Desorption units have been applied in field-portable instrumentation utilized in mobile laboratories (reference 2). Disadvantages of solid sorbent traps are the production of artifacts from the sorbent and non-instantaneous desorption rates. To overcome these limitations, fused silica open tubular columns coated with thick polymer films have been used to

trap analytes (reference 3). Advantages of open tubular traps compared to traditional concentration traps include increase in quantitative reliability and good transfer of analyte between the trap and the analytical column. Fast field air sampling has also been achieved with solid phase microextraction (SPME). Portable dynamic air samplers that draw air across the SPME fiber have been used in the field with sampling times of less than 1 minute (reference 4).

PHASE I: Perform feasibility study to identify and prioritize key performance features required for an on-line, compact, non-cryogenic air/vapor stream sampling system that will provide nonbiased capture, concentration, and transfer of chemical threats for accurate, real-time (or near real-time) detection and identification using GC-MS in swatch test fixtures. The feasibility study should include an initial design for the system.

PHASE II: Generate a detailed design of the system. Report findings, including expected performance features, detailed design, and development plan. Construct a prototype non-cryogenic air/vapor stream sampling system and demonstrate its capability to provide nonbiased capture, concentration, and transfer of chemical threat simulants to a GC-MS for accurate, real-time (or near real-time) detection and identification.

PHASE III: Deliver a working non-cryogenic air/vapor stream sampling system to DPG for testing on Swatch, ERTIC, Mask, and Glove & Boot test fixtures. Assist in integrating the new sampling system with GC-MS and the various test fixtures for detection and identification of toxic chemical threats in high humidity sample streams. Furthermore, demonstrate the new sampling system as a hand-portable sampling system for both on-line and off-line sampling of air in the field for subsequent analysis with hand-portable detectors. Provide training for personnel in both application areas.

PRIVATE SECTOR COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: Private sector applications of the developed technology include (1) use for stationary routine monitoring of workplace and field environments and (2) use by first responders for field detection of toxic chemicals, solvents involved in arson, drugs of abuse, and explosives, as well as detection of volatile and semi-volatile chemicals associated with agricultural, food quality, biomedical, and environmental issues.

REFERENCES:
1. Camel, V.; Caude, M., Trace Enrichment Methods for the Determination of Organic Pollutants in Ambient Air. J. Chromatogr. A 1995, pp 3-19.

2. Eckenrode, B. A., The Application of an Integrated Multifunctional Field-Portable GC/MS System. Field Anal. Chem. Technol. 1998, 2, (1), 3-20.

3. Bicchi, C.; D'"Amato, A.; David, F.; Sandra, P., Capturing of Volatiles Emitted by Living Plants by Means of Thick Film Open Tubular Traps. J. High Resolut. Chromatogr. 1989, 12, 316-321.

4. Hook, G. L.; Lepage, C. J.; Miller, S. I.; Smith, P. A., Dynamic Solid Phase Microextraction for Sampling of Airborne Sarin with Gas Chromatography-Mass Spectrometry for Rapid Field Detection and Quantification. J. Sep. Sci. 2004, 27, 1017-1022.

KEYWORDS: Sampling; concentration; air; chemical threat; toxic industrial chemicals; gas chromatography-mass spectrometry; personal protective equipment; field portable.

CBD09-107 TITLE: Ultra High-Speed Spectroradiometry for Contamination Reconnaissance and Surveillance

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop an ultrafast spectroradiometer for transient thermal event detection at surfaces to provide contamination avoidance and mitigation.

DESCRIPTION: Spectroradiometry in the long wave infrared (LWIR) region (~7-14 microns) affords access to the fundamental vibrational fingerprint region of organic hazards such as chemical warfare agents (CWAs) and most toxic industrial chemicals (TICs). State of the art spectroradiometers are generally based on variants of the

Michelson interferometer coupled to a cryogenically cooled mercury cadmium telluride detector element, and rely on naturally-occurring thermal contrast between a threat cloud and the radiance from the background and/or the atmosphere to effect detection of the infrared fingerprint. The approach is limited in applicability to the situation in which the hazard presents as an airborne vapor plume; however, many battlefield contaminant threats present as terrain or equipment contamination, and present little if any vapor concentration. An approach toward the remote detection of surface contamination includes the use of laser or microwave sources to develop a thermal gradient at the surface, and to exploit the time-dependent dynamic thermal emission process that results from the interaction. In order to take advantage of such dynamic signatures and reliably detect the surface contaminant, extremely rapid spectroradiometry methods are needed.

The state of the art for conventional spectroradiometry is a sampling rate of several score Hz to several hundred Hz for the more advanced sensor systems under development, which rely on either inertial scanning interferometry or on sequential wavelength selection using tunable filters. To effectively measure the dynamics of thermoluminescent signatures, sampling rates on the order of several kHz are indicated. The high scan rates dictate the employment of solid-state components, including such approaches as dispersive optics or spatial or photoelastic modulation.

PHASE I: (Feasibility Study) The Phase I study will thoroughly analyze and model the component and system level performance of a long wave infrared ultrafast (> 10 kHz sampling rate) spectroradiometry approach, and generate an end-to-end theoretical performance model and to drive the preliminary design constraints for a Phase II demonstration system.

PHASE II: (Prototype Delivery) The Phase II effort will fabricate, integrate, test, and optimize the performance of an ultrafast long wave infrared spectroradiometry platform based on the outcome of the Phase I Feasibility Study.

PHASE III DUAL-USE APPLICATIONS: An ultrafast spectroradiometer would realize significant market potential in industrial process control, particularly when applications include a need to assess dynamic events such as materials deposition and curing. The technology would also realize application to environmental remediation, medical diagnostics, and pharmaceutical quality control and analysis.

REFERENCES:

1. Carrieri, A., “Chemical imaging sensor and laser beacon”, Applied Optics, 42(15), 2772-2784 (2003)

2. Carrieri, A. “Panoramic infrared imaging spectroradiometer model with reverse phase-modulated beam broadcasting”, Applied Optics, 36(9), 1952-1964 (1997)

3. Carrieri, A., Barditch, I., Owens, D., Roese, E. Lim, P., Talbard, M., “Tactical thermal luminescence sensor for ground path contamination detection”, US Patent 6464392 issued on October 15, 2002.

4. Carrieri, A. “Remote panoramic infrared-imaging spectroradiometer with integrated encrypted broadcast beacon”, US Patent 7038789 issued on May 2, 2006.

5. Pellerin, C., Snively, C., Chase, D., Rabolt, J., “Performance and Application of a New Planar Array Infrared Spectrograph Operating in the Mid-Infrared (2000–975 cm-1) Fingerprint Region”, Applied Spectroscopy, 58(6), 639-646 (2004).

6. Laubscher, B., Smith, B., Cooke, B., LaDelfe, P., Berggren, R., Villenueve, P., Goeller, R., Obbink, G., Milligan, S., Howard, J., Norton, P., "Infrared imaging spatial heterodyne spectrometer (IRISHS) experiment effort", Proceedings of the SPIE, Vol. 3701, 194 (1999).

7. Voge, P., Primot, J., "Simple infrared Fourier transform spectrometer adapted to low light level and high-speed operation", Optical Engineering, 37(9), 2459-2466 (1998).

8. Buican, T. "Birefringence interferometers for ultra-high speed FT spectrometry and hyperspectral imaging I. Dynamic model of the resonant photoelastic modulator, Vibrational Spectroscopy, 42, 51-58 (2006).

KEYWORDS: remote sensing, hyperspectral imaging, interferometry, infrared spectroradiometry, transient thermal event detection, thermoluminescence

CBD09-108 TITLE: Distributed Thermal Imaging Spectrometer for Force Protection

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop an inexpensive imaging spectroradiometer for hazard plume detection and early warning.

DESCRIPTION: Hyperspectral imaging spectroscopy offers significant benefits in the science of passive infrared remote sensing, but the field has traditionally suffered from inadequate system development and deployment due in part to the limited commercial demand for sophisticated spectral imaging capability. A significant constraint in both military and commercial applications of remote sensing systems is the high component costs associated with traditional hyperspectral imaging systems. Cryogenically cooled focal plane arrays are the principal price drivers for such systems, catapulting the system cost into the hundreds of thousands of dollars, which prohibitively constrains their affordability. The advent of low-cost uncooled thermal imaging focal plane arrays based on microbolometer technology has had a dramatic impact on the thermal imaging industry, enabling the expansion of the use of thermal imagers in Government, industrial and even private applications. However, the responsivity of microbolometer arrays are dependent on high optical throughput, making them useful for fast thermal imaging optics but much less valuable for imaging spectroscopy applications. Novel dispersive optical element technologies have been described for spectral dispersion to effect spectral band selection without sacrificing the high optical throughput of a low F-number camera, making this technology potentially compatible with the microbolometer array. Such a system would be fundamentally less expensive than cryogenically cooled mercury-cadmium telluride systems, allowing for a much more affordable platform that could be widely distributed in Joint Services areas of operation to enable enhanced force protection from chemical warfare agents and toxic industrial chemical threats.

PHASE I: (Feasibility Study) The Phase I study will thoroughly analyze and model the component and system level performance of a long wave infrared hyperspectral imaging spectrometer based on a fast optic (low F-number) microbolometer thermal imager mated to a tunable optical element (e.g., tunable filter or dispersive optical element), to develop an end-to-end theoretical performance model and to drive the preliminary design constraints for a Phase II demonstration system. Objective performance requirements for the system include noise-equivalent spectral radiance (NESR) of 1×10-8 W/(cm2 Sr cm-1) at 4 cm-1 resolution for the 800–1200 cm-1 spectral region. An instantaneous field-of-view (IFOV) on the order of 2 milliradians per pixel for the microbolometer array should be considered as an optical design constraint. Cost target for the complete system including onboard digital signal processing, all optics, electronics, and signal conditioning electronics is <$25,000. Package should be capable of operation on 24V DC vehicle power system or on compatible battery pack for 8-hour periods. Package weight should be constrained to 20 lbs including 8-hour battery pack (12 lbs for vehicle-powered system). Form factor should comprise a tripod-mounted standalone design not to exceed one cubic foot including batteries.

PHASE II: (Prototype Delivery) The Phase II effort will fabricate, integrate, test, and optimize the performance of a low cost, portable long wave infrared hyperspectral imaging platform based on the outcome of the Phase I Feasibility Study.

PHASE III DUAL-USE APPLICATIONS: An inexpensive hyperspectral imaging spectrometer would realize significant market potential in industrial process control, particularly when applications include a need to detect leaks in engineering plants and pipelines. As a consequence of the traditionally high platform cost associated with long wave infrared hyperspecral imaging, the field has numerous untapped applications in mineral and natural resource prospecting, agriculture, pharmaceuticals, semiconductor component manufacture and testing, and advanced materials analysis and development.

REFERENCES:
1. Leijtens, J.; Court, A.; de Boom, K., "Microbolometer spectrometer, the multi purpose smallsat instrument", European Space Agency Special Publication, SP-571 (4S Symposium: Small Satellites, Systems and Services), 26-31 (2004).

2. Christensen, P.; Jakosky, B.; KH.; Malin, M.; McSween Jr., H.,; Nealson, K.; Mehall, G.; Silverman, S.; Ferry, S.; CM.; Ravine, M., "The Thermal Emission Imaging System (THEMIS) for the Mars 2001 Odyssey Mission", Space Science Reviews, 110(1-2), 85-130 (2004).

3. Cole, B.; Fritz, B.; Horning, R., "Fabry-Perot micro filter-detector", US Patent 5,550,373, issued August 27, 1996.

4. Lyons, D.; Whitcomb, K., "Diffractive optic image spectrometer (DOIS)", US Patent 5,986,758, issued November 16, 1999.

5. Lyons, D.; Whitcomb, K., Characterization of the DOIS prototype: a diffractive optic image spectrometer", Proceedings of SPIE-The International Society for Optical Engineering, 2819, 206-217 (1996).

KEYWORDS: remote sensing, hyperspectral imaging, microbolometer array, infrared spectroscopy, interferometry, dispersive optic imaging

CBD09-109 TITLE: Electrostatic, non-fluorescent trigger for aerosolized biological threats using fluctuation enhanced sensing.

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To design, build, and evaluate a trigger for non-fluorescent biological warfare threats using fluctuation enhanced sensing.

DESCRIPTION: Current biological warfare agent detection systems within the chem/bio defense community depend on UV fluorescence to trigger a detection event. Most biological agents possess a strong fluorescence signature that can be utilized both as a trigger and as a detection mechanism. Once the BW agent aerosol enters a sensor and triggers the device with an appropriate fluorescence signature, a series of confirming tests are performed to determine the presence or absence of a BW threat.

Non-fluorescent BW threats, however, pose a problem. Without an appropriate trigger, confirming tests are not performed. Thus false negative responses can occur and may place personnel at risk. For non-fluorescent threats other properties must be utilized to develop a working trigger. One possible method of addressing triggering for non-fluorescent threats relies on the fact that many BW agents are easy to ionize. Ionization can be enhanced by several methods including the use of corona wires and irradiation. The ionization is detected when the charged particles are placed between two electrodes and a very small current is produced.

However, the currents that are produced are miniscule and difficult to detect. Thus one would be required to detect sub-nano-watt fluctuations in a relatively noisy electrostatic environment with high output impedance. The resulting currents are too small to be detected by conventional methods. However, when a large multicharged particle collides with an electrode, a distinctive transient signal is produced. The flow of such transient events generates a stationary stochastic signal which can be related to the BW agent.

It may be possible to use the statistical properties of these stochastic signal patterns associated with the sequence of collision events to produce a triggering device using techniques that were developed for fluctuation enhanced sensing (FES). In FES sensors noise patterns are intentionally enhanced and exploited. This is different from traditional sensing methods where noise patterns are suppressed. In FES noise enhancement is accomplished by modifying the readout electronics to filter out stable, regular signals and to enhance random, irregular, high-frequency signals. The noise is further enhanced using software techniques to generate patterns/signatures using various distribution functions, including higher-order statistics, of the stochastic signal component. The generated patterns of clean agents are used as agent signatures and the measured patterns generated by unknown composition of agents are analyzed by advanced decomposition and pattern generation techniques.

FES has been shown to be a very useful and robust sensing technique for detecting trace quantities of chemical vapors. Higher order statistics provide multidimensional data that can be used for enhancing signals and reducing

false alarms. Extending FES techniques to aerosol detection may provide significant advantages. The goal of this effort is to produce a trigger for a biological detection system based on electrostatic interaction of charged bacterial spores with an FES based sensor that detects very small signals that occur when the charged spores interact with electrodes.

The final goal of this effort is the detection of bacterial spores at very low concentrations. However, higher concentrations will be allowed in the initial demonstration. The goal will be to use the data from this effort to determine concentration detection thresholds. For this effort aerosolized bacillus subtilis spore will be used.

PHASE I: Perform a theoretical exploration of the fundamental and practical limits of detection by the FES method. Take practical parameters into account such as spore charge, spore density, air flow rate, adsorption probability, node capacitance, driving resistance, and amplifier and thermal noise. Based on these results, design a sensor based on electrostatic interactions and fluctuation enhanced sensing that is optimized for the detection of aerosolized bacillus spores.

PHASE II: Build a breadboard system of a fluctuation enhanced sensing unit that utilizes electrostatic interaction to sense for aerosolized bacterial spores. Target the system to the detection of aerosolized bacillus subtilis spore at concentrations of 1000 Agent Containing Particles per Liter of Air (ACPLA) or less. Conduct extensive tests and optimize the system. Compare the results with theoretical expectations. Design improvements, such as a cross correlation technique, for current noise to enhance the sensitivity. Test advanced statistical analysis tools and pattern recognition techniques for further enhancement. Test the sensor against aerosolized spores. Test the sensor against common interferents including aerosolized dust and smoke.

PHASE III: Finalize design and form-factor based on results of breadboard system testing. Construct field deployable system to withstand environmental extremes encountered in field conditions. Test system in realistic ambient environments at appropriate test and evaluation facility.

REFERENCES:
1. K.R.S. Prier, B. Lighthart, and J. J. Bromenshenk, “Adsorption Model of Aerosolized Bacterial Spores (Bacillus subtilis Variety niger) onto Free-Flying Honey Bees (Hymenoptera: Apidae) and its Validation”, Environmental Entomology, Volume 30, Issue 6, December 2001, pages 1188–1194.

2. N. D. Seeley and S. B. Primrose, “The isolation of bacteriophages from the environment”, Journal of Applied Microbiology, Volume 53 Issue 1, August, 1982 Page 1-17.

3. Ulrika Husmark and U. Rönner, “Forces involved in adhesion of Bacillus cereus spores to solid surfaces under different environmental conditions”, Journal of Applied Microbiology, Volume 69, Issue 4, October 1990, Page 557-562.

4. L.B. Kish, J. Smulko, P. Heszler, C.G. Granqvist, "On the sensitivity, selectivity, sensory information and optimal size of resistive chemical sensors", invited paper, Nanotechnology Perceptions 3 (2007) 43–52.

5. Gabor Schmera and Laszlo B. Kish, “Surface diffusion enhanced chemical sensing by surface acoustic waves”, Sensors and Actuators B: Chemical, Volume 93, Issues 1-3, 1 August 2003, Pages 159-163, Proceedings of the Ninth International Meeting on Chemical Sensors.

6. J.M. Smulko, L.B. Kish, “Higher-Order Statistics for Fluctuation-Enhanced Gas-Sensing”, Sensors and Materials 16 (2004) 291-299.

7. Ch. Kwan, G. Schmera, J. Smulko, L.B. Kish, P. Heszler, C.G. Granqvist, "Advanced agent identification at fluctuation-enhanced sensing", IEEE Sensors, in press (2008).

8. J.L. Solis, G.E. Seeton, Li Yingfeng, and L.B. Kish, “Fluctuation-enhanced multiple-gas sensing by commercial Taguchi sensors”, Sensors Journal, IEEE, Volume 5, Issue 6, Dec. 2005, pages 1338- 1345.

9. Sami Gomri, Jean-Luc Seguin, and Khalifa Aguir, "Modeling on oxygen chemisorption-induced noise in metallic oxide gas sensors", Sensors and Actuators B: Chemical, Volume 107, Issue 2, 29 June 2005, Pages 722-729.

10. P. Bruschi, F. Cacialli, A. Nannini, and B. Neri, "Gas and vapour effects on the resistance fluctuation spectra of conducting polymer thin-film resistors", Sensors and actuators. B, Chemical, 1994, vol. 19, issue 1-3, 1994, pages. 421-425.

KEYWORDS: biological detection, bacterial spores, electrostatics, corona wire, noise, fluctuation enhanced sensing, higher order statistics, stochastic signatures

CBD09-110 TITLE: CBRN Sensor and Sensor Netting Algorithms

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop advanced, innovative, robust, real-time algorithms for the integration of passive or active electro-optical sensor detections and identification information, with attention to weighted uncertainties, for advanced chemical warfare (CW) agent defensive warning time capability.

DESCRIPTION: Development of advanced algorithms to improve detection reliability of small threat signals in the presence of highly cluttered composite signals for Chemical Warfare (CW) agent threats. Future networked CW defense system comprised of both standoff and point sensor phenomenology would fuse sensor data in real time to effect higher confidence indicators and accurate mapping of the threats. New innovative algorithms are required to correlate and fuse weighted signal outputs from multiple point and standoff sensors. In addition, the algorithm may assess the value of follow-on tasking of reconnaissance and surveillance assets (e.g., of a UAV-mounted sensor) for warfighter decision support. To provide a single integrated picture of the battle space to the combatant commander, it is necessary to correlate (associate) the information from disparate sensors in the presence of bias and other errors, including position and time errors, and faulty sensor operation (e.g., bad calibration or alignment). Sensor netting algorithms must accommodate real time meteorological data and apply decision logic that accounts for realistic operational conditions (e.g. less-than-perfect sensor performance and health/status reporting assumptions) to mitigate these bias errors and provide a system level capability that manages false alarms while maintaining sufficient network-wide sensitivity to the threat condition. The proposed approach should have the following properties:

1) Use metric data, features, or other data that provides for accurate I.D. and system wide correlation.

2) Provide a measure of confidence with all detection and correlation decisions, at the local and network level, similar to covariance metrics and covariance consistency metrics used in kinematic track processing. Covariance Consistency is the property that a computed variance-covariance matrix realistically represents the covariance of the actual errors of the estimate. The computed covariance of the state estimation error is used in the computations of the data association processing function; consequently, degraded consistency causes mis-associations (correlation errors) that can substantially degrade system level performance. The computed covariance of the state estimation error is also used by downstream functions, such as the network-level resource management functions. Hence, degraded covariance consistency or bias errors can mislead the war fighter about the accuracy of a threat event.

3) Provide metrics to identify groups or classes of threats, along with confidence in classification assessment, in addition, the system should classify threats that are otherwise indistinguishable.

4) Address use of algorithms that allow non traditional sensor and database information (such as terrain, weather, acoustic sensors, etc) to augment real-time sensor data towards refining overall threat assessment and recommended sensor tasking course of actions for improving assessment confidence further.

It is desired that the proposed method can be implemented in either a centralized or distributed architecture.

Proposals that offer improvements to component algorithms, such as bias estimation or search routines, or that enable distributed operations will be considered.

PHASE I: Develop the mathematical basis for and provide a feasibility assessment of track correlation/sensor netting concepts using simulated data and key metrics for a system of point sensors in regions of overlap with the field of regard for standoff sensors (addressing 1-4 above).

PHASE II: Develop/update the technology based on Phase I to provide a prototype demonstration of the technology in a realistic environment using realistic data, with errors and biases as well as realistic processing speeds in complex scenarios.

PHASE III: Integrate algorithm enhancement technology into a CW sensor, Area of Responsibility (AOR) or Combatant Command (CoCom) level network level decision support cell, and/or Major Defense Acquisition Program (MDAP) programs of record. Partnership with traditional DoD prime contractors is encouraged to facilitate successful transition and integration into an operational environment.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable across DoD, as well as in non-DoD sensor network environments such as air traffic control, medical imaging, meteorology, communications, and security applications.

REFERENCES:

1. Defense Threat Reduction Agency, Strategic Plan, http://www.dtra.mil.

2. National Military Strategy to Combat Weapons of Mass Destruction (NMS-CWMD), February 2006; http://www.defenselink.mil/pdf/NMS-CWMD2006.pdf.

3. Cowley, D.C. and Shafai, B., "Registration in Multi-sensor Data Fusion and Tracking", Proceedings of the American Control Conference, June 1993.

4. Y. Bar-Shalom and W.D. Blair, Editors, Multi-Target/Multi-Sensor Tracking: Applications and Advances, Vol. III, Artech House, Norwood, MA, 2000.

5. C. Chong, S. Mori, W. Barker, Architecture and Algorithms for Track Association and Fusion, IEEE AES Systems Magazine, January 2000.

6. Signal and Data Processing of Small Targets 2006, Covariance Consistency, Oliver E. Drummond, Editors, 623615.

KEYWORDS: Algorithm, sensor fusion, sensor netting; data fusion, decision support systems.